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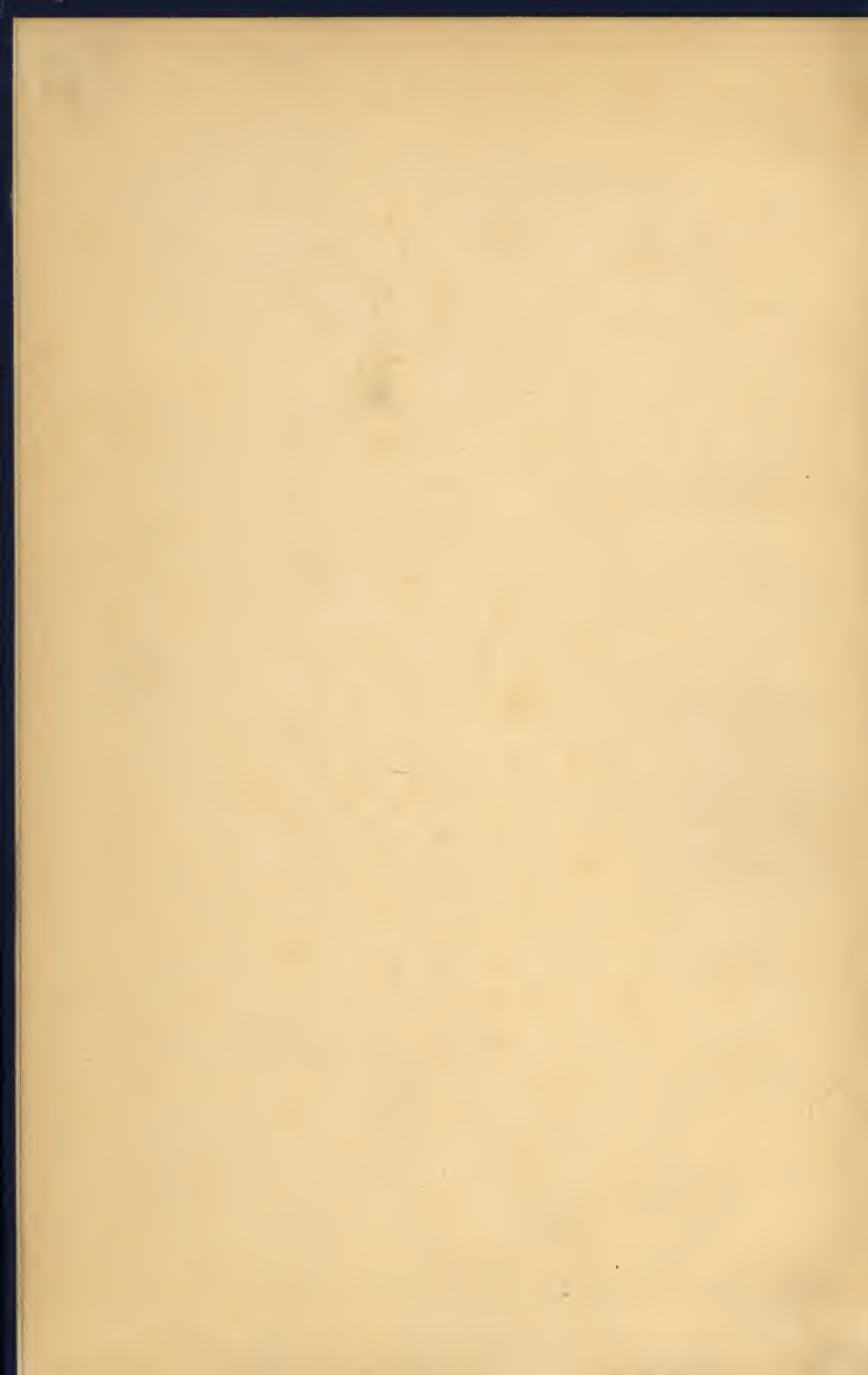
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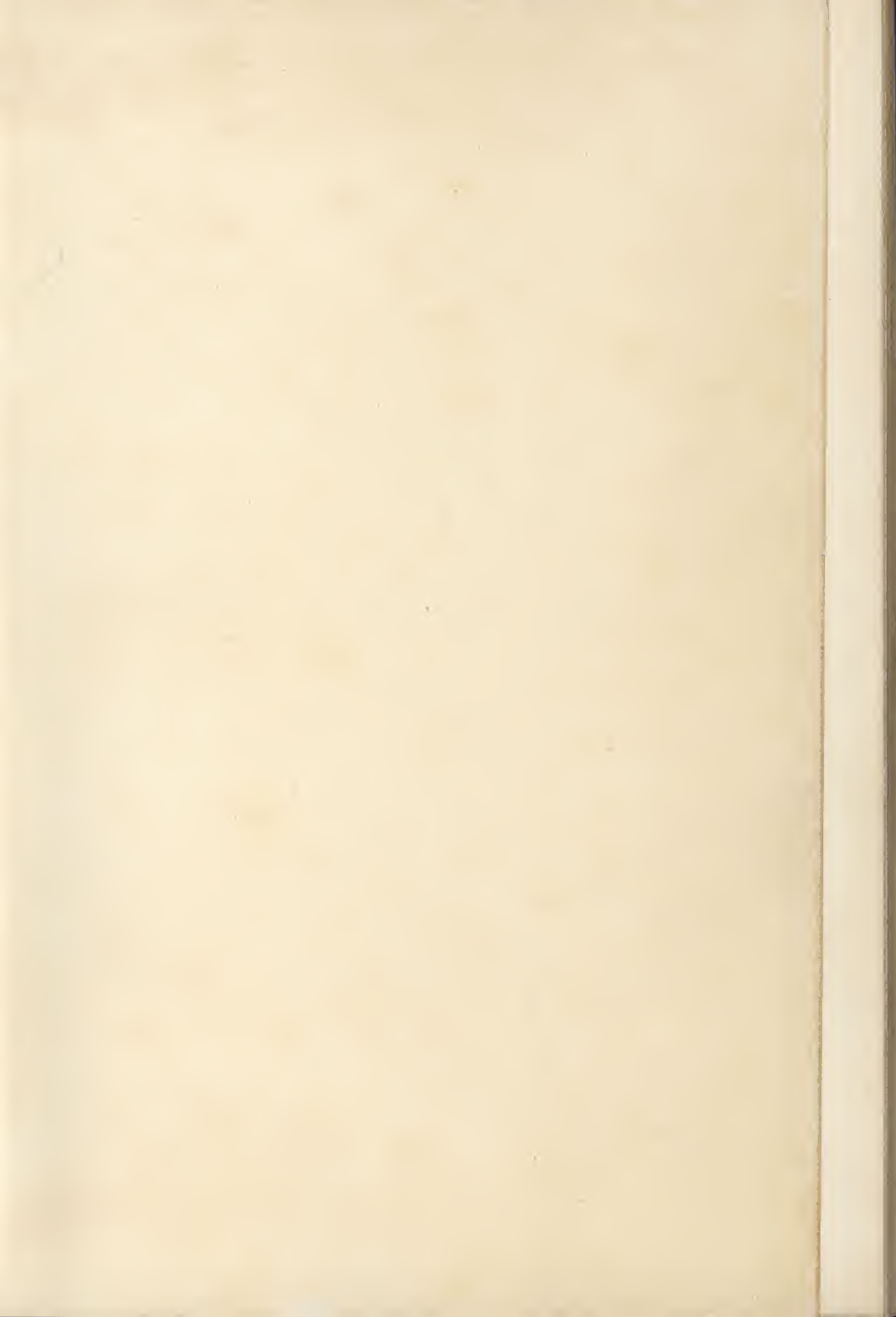
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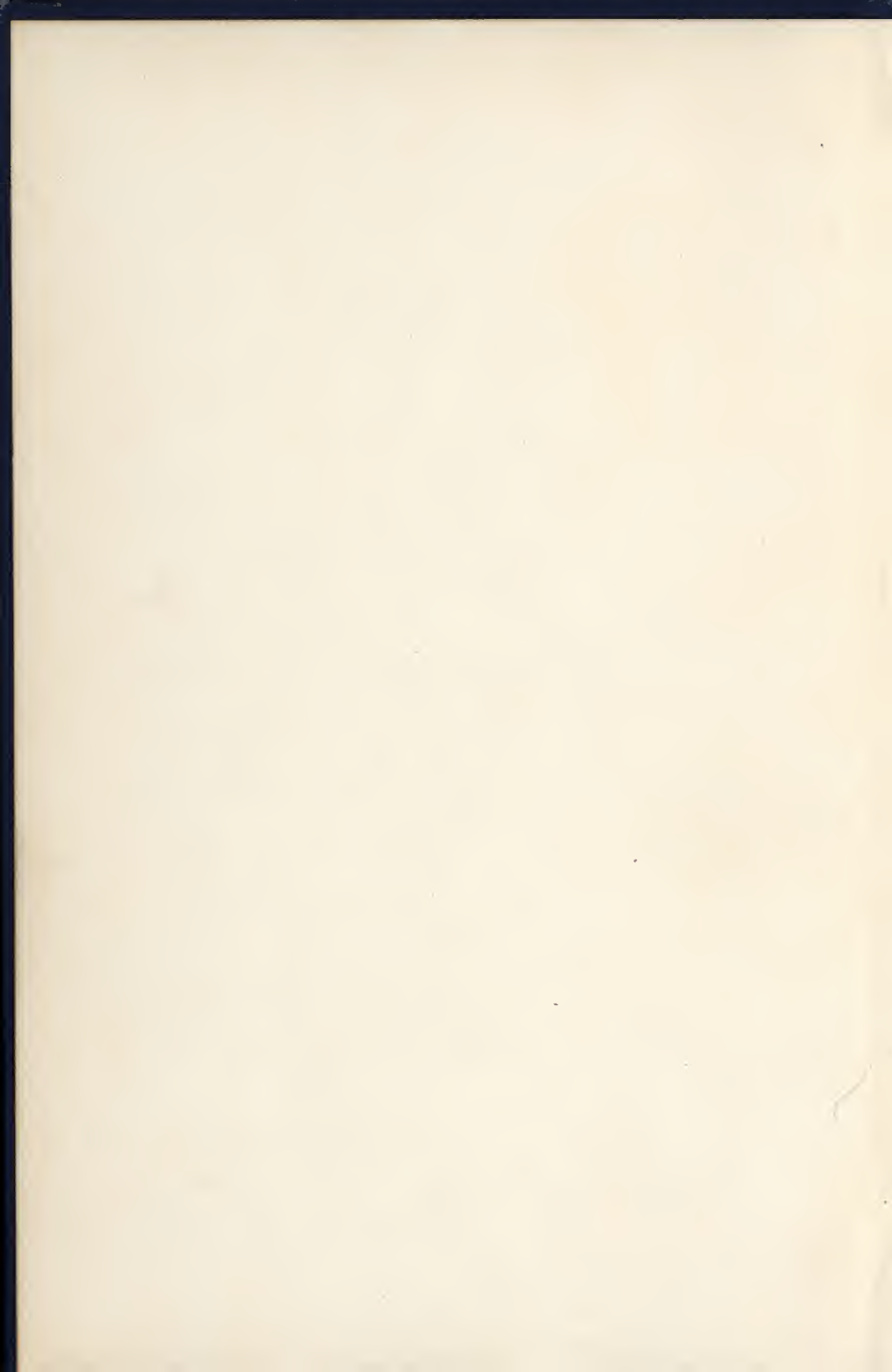
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## FLAT GLASS





LIBBEY-OWENS MAIN FACTORY, CHARLESTON, W. VA.



# FLAT GLASS



BY ARTHUR E. FOWLE, VICE-PRESIDENT AND TREASURER  
THE LIBBEY-OWENS SHEET GLASS CO., TOLEDO, OHIO

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The Libbey-Owens Sheet Glass Co.



## DEDICATION

This story of window glass is dedicated to

IRVING W. COLBURN

without whose inventive genius and untiring efforts in the face of adverse and almost unsurmountable obstacles, this book could not have been written. Through the consummation of his original ideas, the manufacture of *flat glass* has been revolutionized throughout the entire world.

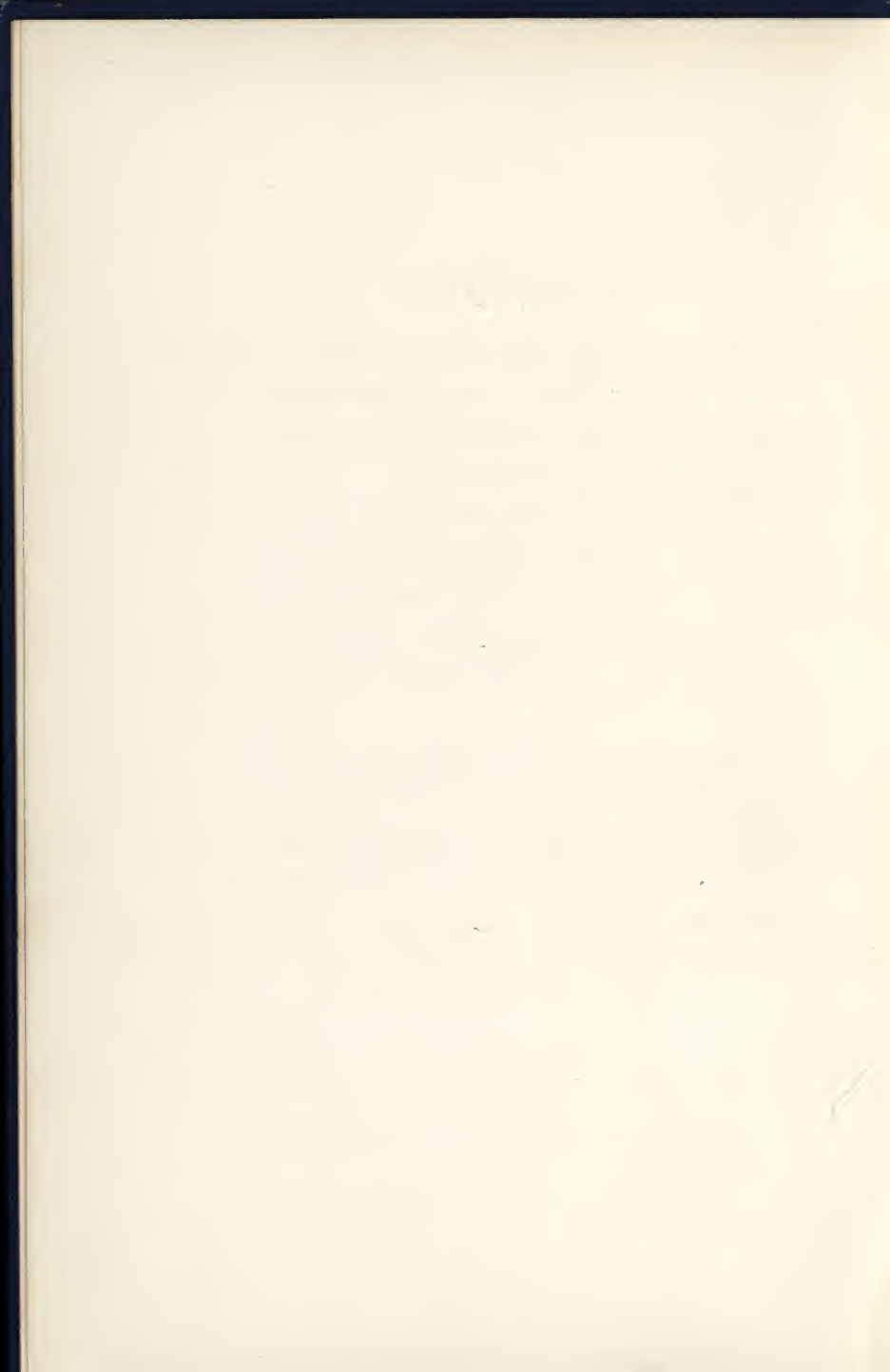
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## FOREWORD

ALTHOUGH there are many books on the subject of glass, none of these deals specifically with *flat glass*, so far as the writer has been able to learn.

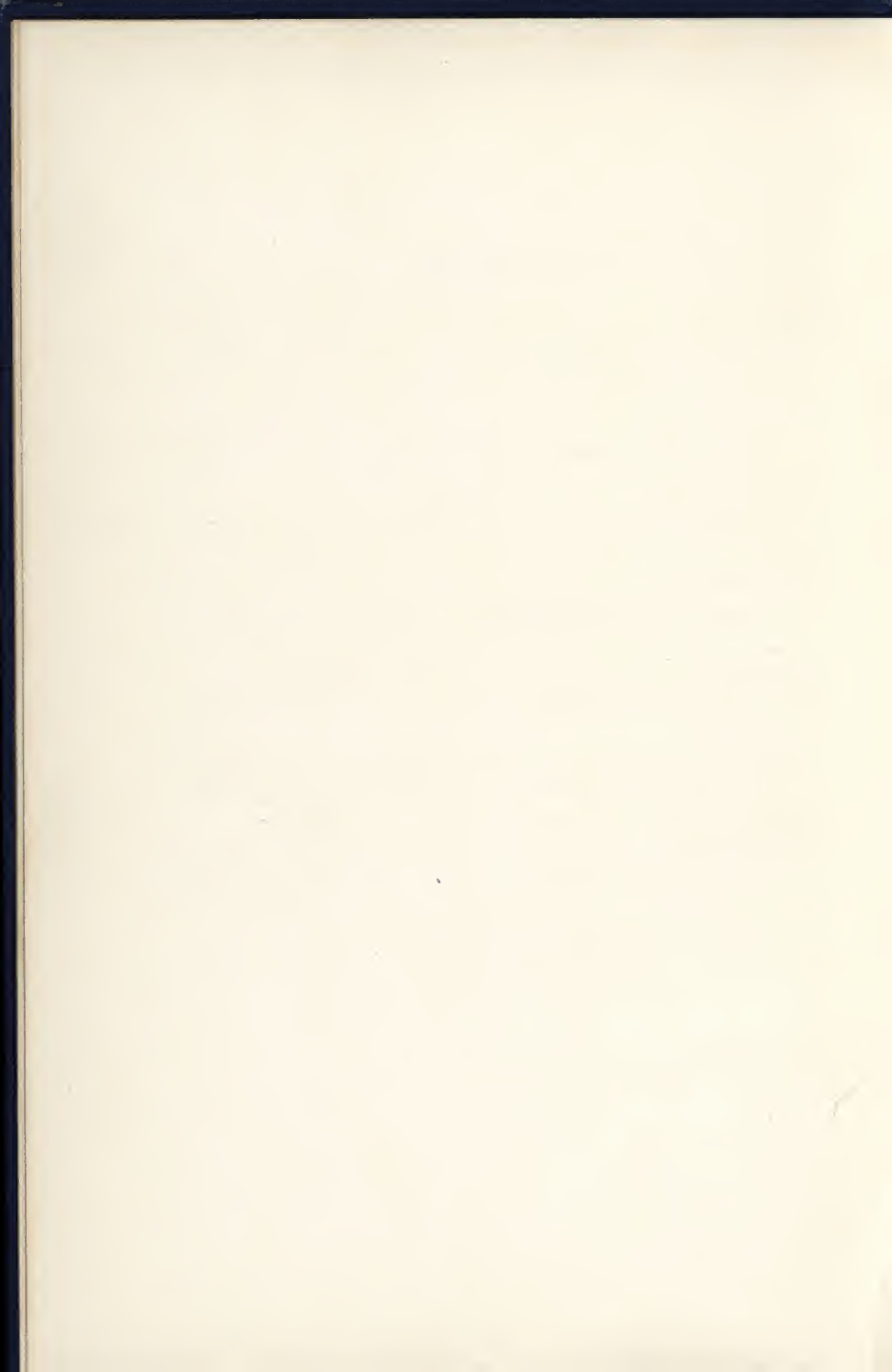
The story is, nevertheless, one of unusual interest and the advent and perfection of the Colburn machine for producing flat-drawn sheet glass is a particularly interesting phase of that story.

This book therefore aims to give a comprehensive account of flat glass. It also describes the development of the Colburn process, which has revolutionized the industry.



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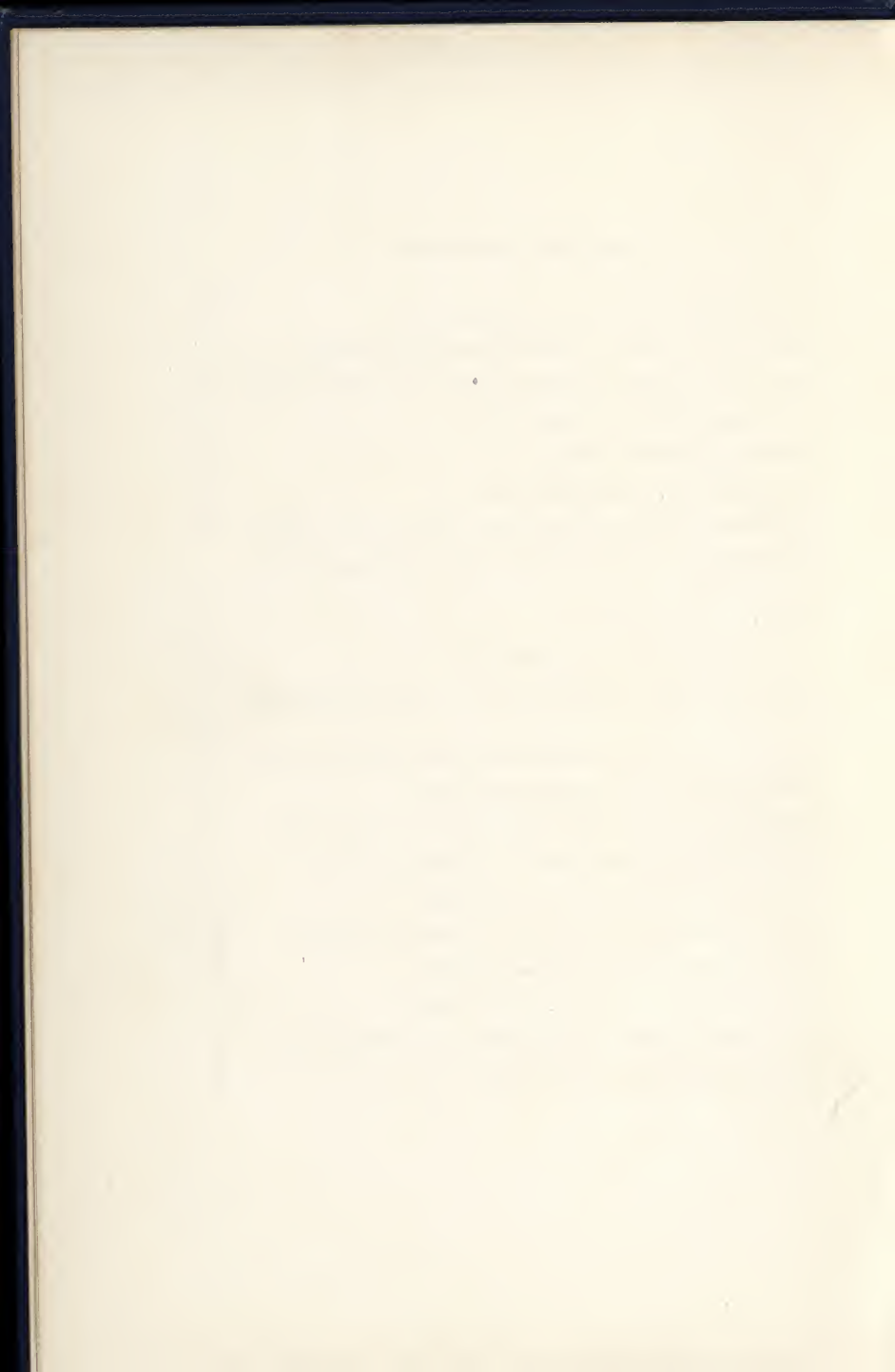
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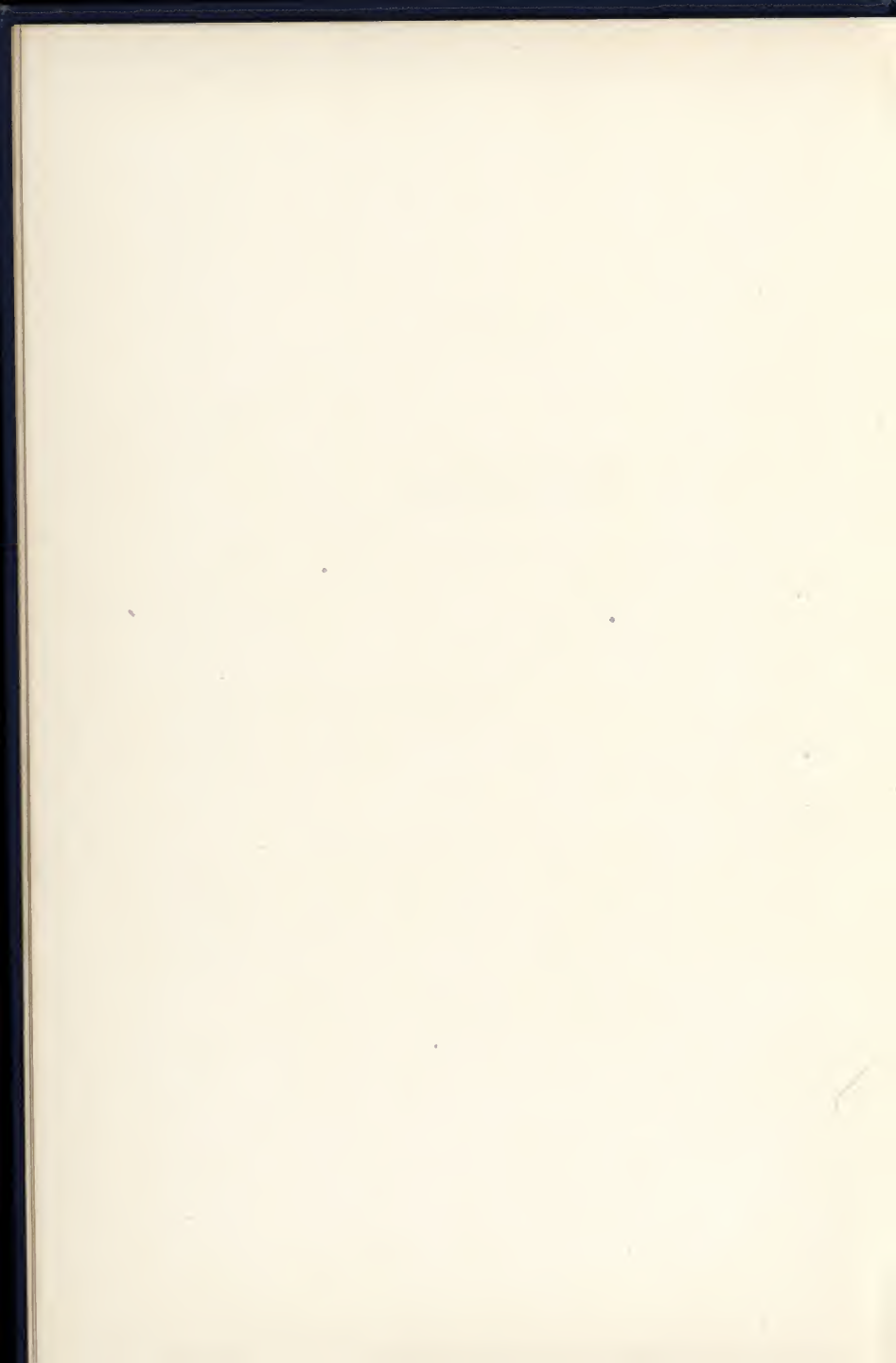


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## FLAT GLASS



## CHAPTER I

### EARLY HISTORY OF FLAT GLASS

LAT glass in some form has existed from the earliest times. Only in the last few centuries, however, has it been manufactured in sufficient quantity and at a cost low enough to make it available for general use.

It is interesting to note that the term "flat glass" until very recent years has been a misnomer. All of this so-called flat glass for use in windows and for similar purposes, with the exception of plate glass, which does not come within the province of our story, was slightly "bowed." It was not until an entirely new process of manufacture was perfected that absolutely flat glass was made available to the world.

## FLAT GLASS

Glass bottles, jars and vases, since the time of the earliest records, have been a very important commodity of commerce, and at first thought it might seem that the production of these various shaped glass articles of ancient origin, which are seen in our museums, was more difficult than the production of the common glass window as we know it today; but this is not the case.

The fact is that the quality of the metal itself entering into common window glass must obviously be far superior in clearness and strength to the metal used for ordinary "blown ware." At the same time the mechanical difficulties entering into the production of flat glass are far greater.

Hence it is not to be wondered at that the world was obliged to wait patiently for centuries for the flat glass which today is so indispensable to human living.

Glass was used most extensively by the Romans and its adaption to windows was just

## EARLY HISTORY OF FLAT GLASS

beginning when Roman civilization was overwhelmed by the northern barbarians. Glass was largely used by the Romans in pavements and in thin plates as a coating for walls. It was used to some extent in windows, but mica, alabaster and shells were more widely employed.

Such glass as was used for windows was very thick and was available only in small pieces. The ruins of Pompeii reveal that glass half an inch thick was used in the windows of the famous baths. Other traces of Roman glass have been found in Roman ruins at London. Most of the pieces had evidently been made by casting, and the discovery of sheet glass at Silchester shows that this process of making glass was known at that time.

When Justinian built the church of St. Sophia at Constantinople in the fifth century, there were provided great window openings filled with pierced marble screens or frames fitted with small pieces of semi-opaque flat glass, probably produced by casting.





HAND PROCESS OF MAKING WINDOW GLASS: BLOWING THE BALL



## EARLY HISTORY OF FLAT GLASS

The first mention of the use of glazed windows in Great Britain was in the seventh century when Benedict of Wearmouth sent to France for workmen to glaze a church that he was building.

The use of stained glass in small pieces for leaded windows was characteristic of the Gothic cathedrals in the twelfth and thirteenth centuries. The old masters who mixed the colors for the variety of shades required in this wonderful art of the medieval stained glass windows attained a degree of skill that appears to have died with them, for we are forced to admit that our modern artisans cannot produce the depths of color and variety of shades attained in those times. This is especially true of the deep blues and purples found today in so many of the old world cathedrals and churches.

These instances of the limited use of flat glass in window openings did not mean windows in the modern sense—far from it.

## FLAT GLASS

When Edward I brought back his bride from Spain, his father, Henry III, was so delighted with little Eleanor, then in her teens, that he made the youthful couple a present of a house furnished with glazed windows, special mention in the narrative of the day being made of the glazing of the windows.

Pope Pius II, in 1448, expressed surprise in finding at Vienna church windows fitted with flat glass.

In 1467 there were ordered, for the Duke of Burgundy's palace, twenty pieces of wood with which to make frames to be fitted with paper for chamber windows.

In the reign of Elizabeth, the Duke of Northumberland, on leaving his estate, was warned by his steward that he had better order the windows taken out of his house and stored in safe keeping until his return—a significant illustration of the value and importance of a few glass windows even in the grandest habitations of that day. Even

## EARLY HISTORY OF FLAT GLASS

the luxury loving Charles II (1660–1685) had no glazed windows in his palace.

At the close of the eighteenth century, shortly after the Revolutionary War, there existed in Paris, the world's most civilized capital, a large corporation engaged in the manufacture of window sashes fitted with oiled paper.

Both France and Belgium reverted to this expedient for enclosing their houses during the first days of reconstruction after the close of the World War—all of the window glass factories being destroyed or unable to resume operations.

The use of flat glass for windows did not become general until the eighteenth century.

An indication of the fact that windows were regarded as a luxury is found in the "window tax" that was levied on these openings by the English government of the seventeenth and eighteenth centuries. A similar tax still is levied in France.



HAND PROCESS OF MAKING WINDOW GLASS: BLOWING THE CYLINDERS

## CHAPTER II

### FLAT GLASS IN AMERICA

**D**EVELOPMENT of flat glass was slow in the New World as well as in the Old, until the modern era of industry arrived. Probably the first attempt to manufacture window glass in the United States was in Allowaystown, New Jersey, in 1738. This venture was unsuccessful as was a later attempt by Robert Hewes, who, in 1790, started a small window glass factory in a forest near Concord, New Hampshire. A few years later, in 1797, Gallatin and Company started a window glass factory in New Geneva, Pennsylvania, ninety miles south of Pittsburgh. This factory proved fairly profitable, the glass at that time selling for \$7.00 per box of fifty feet, 10 inches by 10 inches in size.



## FLAT GLASS

The use of coal as fuel in glass-making brought a decided change. Previously the industry had been a wandering one, moving from place to place as the need for fresh fuel arose. The use of coal made possible steady development at one place.

O'Hara and Craig established at Pittsburgh in 1797 the first window glass plant to use coal.

The first really successful window glass factory in the United States was that of the Boston Crown Glass Company of Boston, Massachusetts. Chartered in 1787, it began operations in 1792, under very favorable conditions, being greatly assisted by the liberal action of the state legislature.

The legislature exempted the company from taxes and their workmen from military duty. It also gave them exclusive rights for fifteen years to manufacture window glass in Massachusetts.

In 1798, records show that this company produced window glass to the value of \$82,000.

## FLAT GLASS IN AMERICA

The glass made at this factory was said to be superior to the imported article and was well known among the trade of that time as "Boston crown window glass." Specimens of this old crown glass can be seen today in many of the old Colonial houses in New England.

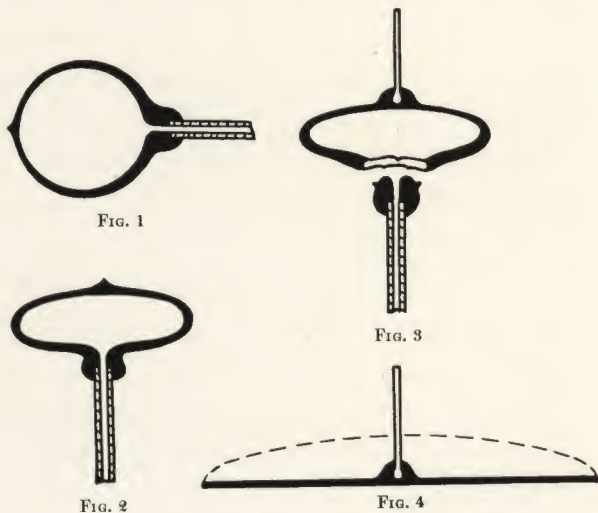
The use of glass for windows was by this time becoming widespread. The American pioneers who pushed their way across the western frontiers each carried a small four-paned window, which the homestead law of the time required to be built into every cabin.

This general use of glass was made possible by better methods of manufacture. The casting process for making flat glass never attained commercial possibilities. The first real window glass was made by the blowing process and was known as "crown glass."

This process consisted in gathering a large globule of molten glass on the end of a blow-pipe, the glass then being blown into hollow

## FLAT GLASS

spherical shapes (Figs. 1 and 2). Next a punty or iron rod, tipped with molten glass, was applied to the opposite side of the sphere and



FOUR STAGES OF MAKING "CROWN GLASS"

the blowpipe was detached, thus leaving a hole (Fig. 3).

The globe attached to the punty was then reheated and the punty given a whirling



## FLAT GLASS IN AMERICA


motion that caused the glass to flash outwardly into the form of a disc, adhering to the punty by the boss in the center (Fig. 4.). The disc was removed from the punty, annealed in an oven and then cut into small sheets. The centers of the discs containing the bosses or "bull's-eyes" were used for decorative effects and were employed largely in the sidelights and transom lights of the Colonial doorways of New England.

This method of making flat glass was obviously very expensive and wasteful and furthermore did not make possible the production of anything but very small lights.



## CHAPTER III

### THE HAND PROCESS

HEETS of flat glass made by the process described in the previous chapter were necessarily limited in size and very expensive. This furnished a great incentive to the study of modifications and development of the method so that larger sizes could be produced and at less cost.

The so-called "hand process" of blowing glass in a cylinder form and its subsequent flattening, as we know it today, is a slight advance over the old crown glass method. It is uncertain when this hand process was first started. Mention is made of its being used as far back as the eleventh century, but it did not come into general use until early in the nineteenth century. This hand process con-

## FLAT GLASS

tinued to be the accepted method for making window glass until about 1903.

A brief description of this process is of interest in order to indicate the great skill and arduous labor necessary to produce the so-called flat glass by this method.

The blower, gatherer and snapper constitute what is known as a "shop" in this trade. The gatherer, using a heavy blowpipe about five feet long, gathers a small ball of molten glass on the end, removes it from the furnace, blows it slightly and then gathers more glass (Fig. 1). This operation is repeated four or five times until he gathers sufficient glass to produce a cylinder of the desired size. The ball thus gathered weighs from twenty to forty pounds, according to the size of the cylinder to be produced.

The gatherer carries the blowpipe with the adhering mass of semiplastic glass to the "blower's block," an iron mold set in water and lined with charcoal to prevent the surface

## THE HAND PROCESS

of the ball from becoming marred by direct contact with the iron. The gatherer then blows into the pipe while giving the ball and pipe a



FIG. 1.



FIG. 4



FIG. 2

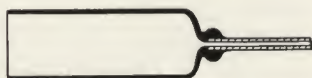


FIG. 5



FIG. 3

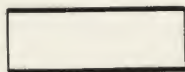


FIG. 6

SIX STAGES OF "HAND CYLINDER PROCESS"

rotary motion on the block, at the same time pulling it upwards in an inclined direction (Fig. 2 and 3). By this means the ball assumes a pear shape and thus forms what is known as





HAND PROCESS OF MAKING WINDOW GLASS: CAPPING OFF THE CYLINDERS

## THE HAND PROCESS

the "neck" of the cylinder in which condition the pipe with the pear-shaped mass of glass is passed to the "blower" who reheats the mass at the blow furnace and then swings the pipe over the "swing hole," or alley, alongside of the furnace.

By highly skillful heating, blowing, reheating and dexterous manipulations, the cylinder is elongated, the sides being kept as nearly as possible to the desired thickness necessary to produce either single, double or heavier sheets.

These intermittent operations are carried on until the bottom of the cylinder is of the same thickness as are the sides. This closed end is then exposed to the heat of the blow furnace while the workman at the same time blows into the pipe and then by placing his thumb over the end confines the air under slight pressure. The air, being expanded by the heat from the furnace, finally bursts out through the bottom (Fig. 4). The cylinder with its ragged, open end, thus produced, is again

## FLAT GLASS

swung out into the "swing hole" in such a manner as to make it completely cylindrical to the end (Fig. 5).

The blowpipe with the completed cylinder still attached by the neck is next passed to the "snapper" who removes the pipe by touching a cold iron to the glass close to the point of the pear-shaped neck or cap. The cap is then cut off by applying a thread of hot molten glass around the cylinder at the shoulder and again applying a cold iron (Fig. 6). The completed cylinder, thus produced, is split open longitudinally by passing a hot iron back and forth along the inside and subsequently applying a cold iron. Cylinders thus formed vary in size from twelve inches in diameter by fifty inches in length to twenty inches in diameter and seventy inches in length.

The cracked open cylinder in this form is then ready for the "flattening process"—another very difficult and highly skilled step in



## THE HAND PROCESS

the production of sheet glass by this method. The cylinder is laid on a light iron carriage and carefully introduced into the heated interior of the flattening oven and when sufficiently heated it is lifted from the carriage by long iron tools and placed on the flattening stone, a large fire clay slab with a well-polished surface. The split cylinder gradually softens and by means of other tools is spread out upon the stone and then ironed or flattened by rubbing with a block of wood mounted on a long iron handle.

The "flattening table" containing the stone is revolved and the stone then moved into a cooler chamber, another stone being moved into the hot flattening oven ready to receive another cylinder and the process repeated. The flattened sheet is now picked up by a long-handled fork and placed in the hot end of the annealing oven or lehr, through which it gradually passes, during the annealing process, towards the cool end. The sheets are then re-

## FLAT GLASS

moved and dipped for a few seconds in a hot bath of diluted hydrochloric acid. This dipping process arrests any further action of the alkali that is used in the original glass batch and prevents the glass fading through the action of the elements.

A little reflection upon the physical characteristics of the split cylinder in passing from its cylindrical form to the flat sheet is interesting. It can readily be seen that in the flattening process previously described, the attempt is made to force the inside circumference to equal that of the outside. This is manifestly impossible since the glass cylinder is heated only to the bending point.

The result of this fact alone is that this ironing out or flattening process cannot produce an absolutely flat sheet of glass and the finished sheet will have an appearance similar to hammered brass or else it will be full of long, irregular waves. Both conditions produce unpleasant effects of distortion

## THE HAND PROCESS

when objects are seen through glass made in this way.

Other defects quite prevalent in cylinder glass, which of necessity requires the flattening process, are the "burns" or marks caused by the sheet of glass coming in contact with an excessively hot or dirty flattening stone. In addition to the foregoing and as a further result of attempting to make the outside and inside circumference of the cylinder equal in the flattened sheet, the sheets are always noticeably bowed or bent.

On this account the sheets of glass always have to be laid the same way in the packing boxes in order to minimize the inevitable breakage in shipment. Furthermore, in subsequent glazing, the glass made by this method, either by hand or by the more advanced cylinder machine process, must be placed in the sash with the bowed side out.

The hand cylinder process of making sheet glass has been the accepted method for many



HAND PROCESS OF MAKING WINDOW GLASS: CRACKING OPEN THE CYLINDERS



## THE HAND PROCESS

years and even in our present day of progress it is still used extensively in many countries of Europe, while in the United States approximately one-third of our window glass is produced by this method which, however, is fast becoming obsolete on account of the recent developments in the art.

It is evident that while the hand cylinder process is an advance in a commercial way over the old crown process, the method is still very expensive and obviously laborious and hard upon the workmen.


The artisans employed in the manufacture of sheet glass by this process have for years jealously guarded their trade, allowing only a limited number of apprentices. They have rigorous rules and regulations in respect to the teaching of these apprentices to follow in the footsteps of the older men, who are forced to abandon their trade prematurely because of its rigorous demands. Here again is seen ample reason for study and experiment in order to

## FLAT GLASS

find a way of reducing this tremendous amount of arduous labor and so work was begun in the early Nineties on a mechanical method for eliminating the human gatherers, blowers, and snappers.

## CHAPTER IV

### MACHINE CYLINDER DEVELOPMENTS

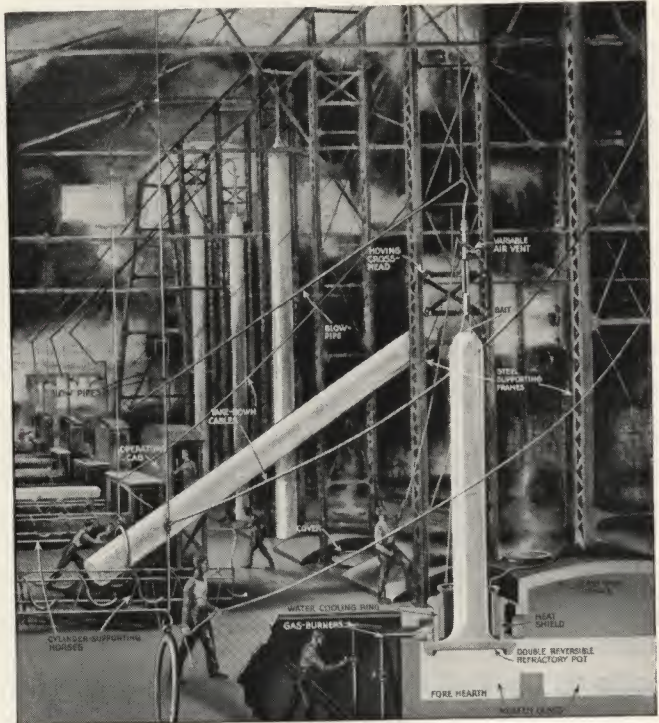
BOUT 1896 J. H. Lubbers, a window glass flattener by trade, began experimenting on a machine wherein the air was mechanically introduced into the blowpipe while the pipe was raised on guides during the formation of the cylinder. The process looked very simple but it took years of effort and several million dollars to bring this machine cylinder process to the point where it is today.

While this method is a step in advance of the hand process, as it eliminates the arduous work of the gatherer, the blower and the snapper, makes better and cheaper glass and produces larger sheets, the product is still



## FLAT GLASS


“cylinder glass” and the cylinders must pass through the same troublesome flattening process that produces the same defects as in glass made by the hand process.



MACHINE CYLINDER PROCESS

## CHAPTER V

### THE COLBURN DEVELOPMENTS

T IS therefore quite obvious that the logical method of making sheet glass is to make it in flat form at the outset. One naturally asks: "Why make it round and then change its form to a flat sheet?" Books could be written on the study and experimentation of drawing glass in sheet form. There is on file a British patent taken out by a man named Clark, February 19, 1857, and a very similar Belgian patent taken out by a man named Loup, March 12, 1857. These were followed by an extraordinarily large number of patents on sheet glass from that time to the present and it can be well said that there is hardly another industry today in which such a wealth of study, effort and money has been

## FLAT GLASS

expended; and finally there was accomplished what the majority of practical glass men were ever claiming as the impossible—the Colburn sheet glass machine as perfected today by The Libbey-Owens Sheet Glass Company.



I. W. COLBURN'S FACTORY AT FRANKLIN, PENNSYLVANIA

The inventor of the process, Irving W. Colburn, became interested in glass in 1898 and started a small experimental plant at Blackford, near Philadelphia, Pennsylvania, where he worked on a machine for blowing lamp chimneys and tumblers. After working two years and expending \$17,000, he abandoned this work and moved to a small plant at

## THE COLBURN DEVELOPMENTS

Franklin, Pennsylvania, where he interested some of his friends in assisting him to carry on his experiments from 1901 to 1905, on an idea he had for a machine to blow cylinder glass. His ideas proved to be merely fantastic dreams and while he did succeed in mechanically producing a few cylinders, they were of poor quality and the cost of operation was prohibitive. During these six years he continually had in mind the idea of producing glass in sheet form by mechanical means without the necessity of first making it in the cylindrical form.

We find now that this idea has been in the minds of many glass men, both here and in other countries, for the past half century as evidenced by the array of paper patents on sheet glass from the patents of Clark and Loup in 1857 up to the present day. It remained, however, for Colburn to give to the world the first workable machine producing commercial flat-drawn sheet glass. His first idea embodied



## FLAT GLASS

in the present machine occurred to him in 1905 when he witnessed a paper-making machine in operation.

Colburn was a man who invariably had ideas in advance of his fellows and had the faculty of surrounding himself with close friends who always seemed willing to give a ready ear to his ideas as well as to assist him in a financial way. He discussed with many of these friends his ideas of making sheet glass, after having seen the paper machine in operation, and succeeded in securing addi-



FACTORY OF COLBURN MACHINE GLASS CO. AT REYNOLDSVILLE, PA., 1907

## THE COLBURN DEVELOPMENTS



REYNOLDSVILLE, PA., FACTORY, SHOWING FURNACE, MACHINE AND LEHR

tional financial backing; and in August, 1906, formed the Colburn Machine Glass Company. During the following two years he built many machines, crude at first, but gradually approaching a solution of the difficult problems with which he found himself confronted. With him, as with many inventors, success was always just ahead, leading him on like the will-o'-the-wisp. He, however, had the inventor's temperament: always hopeful,

## FLAT GLASS

always confident of ultimate success and endowed with a wonderful determination to accomplish his end.

Strange as it appears today, the process was thought to be a success in 1908 and the Colburn Machine Glass Company granted a license for the use of one machine to a company at Reynoldsville, Pennsylvania. The newspapers of the day carried glowing accounts of the possibilities of the Colburn machine. The new plant started off under apparently very favorable conditions but it was soon proved that the end of the journey was a long way ahead.

The trials and tribulations of Colburn and his friends during the following four years form a pathetic story.

Machine after machine, furnace after furnace, was built, torn down and rebuilt, until in all, from 1905 to 1912, fifteen different machines had been constructed and more than \$1,000,000 expended with only a few



## THE COLBURN DEVELOPMENTS

thousand boxes of poor quality glass to show for the tremendous outlay of human effort as well as money.


In 1911 the credit of the Colburn Machine Glass Company was gone; the company was declared bankrupt and its assets, including the numerous domestic and foreign patents of Colburn, were put up at public auction on February 8, 1912, at Pittsburgh.



LIBBEY-OWENS PROCESS: FEEDING THE FURNACES

## CHAPTER VI

### THE LIBBEY-OWENS COMPANY

FTER years of effort and the expenditure of a large amount of money, Colburn's friends finally lost confidence in his process, though they still retained their faith in him.

Practically all of the many window glass manufacturers who had followed his experiments up to the day the patents were put up at public auction regarded the patents as of no value. There was one man, however, who had the vision and clear insight to see just what was needed in the process to make it an undoubted success. That man was Michael J. Owens, the master inventive mind in the American glass industry for the last twenty-five years.

## FLAT GLASS

Through his efforts and earnest, persistent recommendations to Edward D. Libbey, his associate for many years, he induced The Toledo Glass Company, of which Mr. Libbey was president, to purchase the Colburn patents from the trustee in bankruptcy. The purchase of these patents by The Toledo Glass Company in 1912 marks an epoch in the



EXPERIMENTAL FACTORY OF THE TOLEDO GLASS CO., TOLEDO, OHIO

## THE LIBBEY-OWENS COMPANY

history of the window glass industry of the United States as well as throughout all countries of the world where window glass is manufactured.

The Toledo Glass Company immediately began the erection of a very complete experimental, one-machine plant at Toledo, Ohio, beginning operations in November, 1913. They soon found that there was much to be done and still much to learn in order to perfect the process.

As close as The Toledo Glass Company was to success during 1915, the late Mr. James Chambers, who might well be called the father of the American window glass industry, was practically the only manufacturer who had faith in the ultimate success of the process. Practically all others who were privileged to witness the two years' experiments at Toledo were not backward in stating that Mr. Libbey, Mr. Owens and their associates were foolish in spending such sums of money



## FLAT GLASS



INTERIOR OF LIBBEY-OWENS FACTORY AT CHARLESTON, W. VA.

on the much-maligned Colburn machine. Mr. Libbey, however, with his usual foresight, as evidenced in directing other projects of a similar nature, brought to bear on the problem his splendid courage, faith and perseverance, and as a result success was finally attained.

The connection of The Toledo Glass Company with the Colburn sheet glass machine was very similar to its earlier connection with

## THE LIBBEY-OWENS COMPANY

the Owens Bottle Machine, which it developed under similar circumstances and later sold to The Owens Bottle Company. In the early spring of 1916, after having spent well over \$1,000,000, it was quite evident to those in charge of the experiments that success would soon be assured.

This happy conclusion was reached in May, 1916, when The Libbey-Owens Sheet Glass Company was formed and bought from The Toledo Glass Company all of its patent rights, both domestic and foreign, covering the sheet glass machine. One condition of this sale was the reward received by Colburn for his years of effort in the development of the machine. The Toledo Glass Company assigned to him a very liberal stock interest in the new company, which enabled him to discharge the many obligations assumed during the earlier years of his work, as well as to provide liberally for his family.




## FLAT GLASS

The Libbey-Owens Sheet Glass Company immediately began the erection of a six-unit plant at Charleston, West Virginia, at an expense of \$1,500,000, and commenced drawing glass in October, 1917. By a strange irony of fate Mr. Colburn's life was cut short at this time just at the fruition of his many years of effort.

The success of the company was assured from the start, and the demand for its superior product so increased that in 1920 the plant was doubled in size and further enlarged in 1923, making it the largest as well as the best equipped window glass plant in the world today, representing an investment of more than \$7,000,000. The plant is equipped with eighteen Colburn machines and has a capacity of 3,000,000 fifty-foot boxes of window glass a year.

## CHAPTER VII

### THE LIBBEY-OWENS PROCESS

ITH the history of flat glass thus outlined in the previous chapters, it should be of interest now to consider in detail the Libbey-Owens process for making flat-drawn sheet glass.

The preliminary operations are very similar to those in other forms of glass manufacture. The mixture of the ingredients, called the batch, composed of sand, ground limestone, soda ash and salt cake, with a certain amount of cullet or broken glass, is fed into the furnace and melted under a heat of about 2,500 degrees Fahrenheit. The furnace contains from 600 to 900 tons of molten glass. This molten glass passes from the melting chamber to the refining chamber, where it is gradually settled



LIBBEY-OWENS PROCESS: CLOSE-UP OF MACHINE

## THE LIBBEY-OWENS PROCESS

or refined, preparatory to entering the shallow drawing pot from which the sheet is drawn.

This pot or pan is suitably placed in a pot chamber and supported upon silica brick stools. By means of heat applied underneath and around the edges of the pot, the temperature of the glass is carefully maintained at the proper degree of heat for the ultimate formation of the sheet.

To start the drawing of the sheet, the machine is placed in reverse motion, which allows a bait to be introduced into the drawing pot containing the molten glass. The bait is a simple affair consisting of a flat iron bar three inches wide and about six feet long, attached to strips of flexible metal that allow the bait to pass over the bending roll, down into the glass. The molten glass immediately adheres to this bar. Then the machine is placed in forward motion, thus pulling the bait with its adhering mass of plastic glass over the bending roll onto the horizontal flattening table and



LIBBEY-OWENS PROCESS: THE "LEHR" OR ANNEALING CHAMBER



## THE LIBBEY-OWENS PROCESS

thence into the lehr. When the bait reaches the end of the flattening table, about ten feet from the bending roll, it is cracked off and removed and the sheet of glass is allowed to continue on its way through the 200-foot annealing lehr.

The natural question that arises when describing the formation of the sheet of glass in the Colburn machine is: "Why doesn't the sheet pull to a point? What is it that sustains it at a constant width?"

The answer is that the sheet is kept at an even width by passing the outer edges of the sheet between two sets of water-cooled, knurled rolls, placed an inch or two above the surface of the molten glass, just inside the edges of the drawing pot. These knurled rolls engage the sheet for about two inches on each side and serve to sustain it at a constant predetermined width. These edges are thicker than the intervening sheet of glass. The real pulling of the sheet is accomplished by engaging the outer edges of the sheet—after it



## FLAT GLASS

passes over the bending roll—between the flattening table and a series of grip bars running in the same direction and placed just above the flattening table.

The lehr is provided with two hundred power driven rolls, covered with asbestos composition, over which the glass passes in continuous sheet form, emerging at the end onto a movable cutting table. Here it is cut into sheets of suitable size, dipped in a hot solution of hydrochloric acid and then distributed to the several cutting stalls. Experienced cutters then carefully select sheets, grade them and cut them into commercial sizes. These are packed with straw in boxes each containing fifty square feet of glass, regardless of the size of the sheets.

Sheet glass made by this process is absolutely flat, of uniform thickness, and is free from the distortions so common and annoying in all glass made by either the hand process or the cylinder machine process. It thus reaches

## THE LIBBEY-OWENS PROCESS

the user with a natural fire finish, and without the defects inherent in glass made by the flattening or ironing out methods, employed by all other processes.

The machine will make glass from  $1/24$  of an inch to  $5/16$  of an inch thick, the thickness being governed by the temperature of the glass in the drawing pot and the speed of the machine which varies from twenty-five to one hundred inches a minute, according to the thickness of the sheet being pulled. The capacity of one machine is six hundred fifty-foot boxes of single strength glass in twenty-four hours.


It can readily be seen that the Libbey-Owens process of making sheet glass is practically automatic and eliminates the greater part of the strenuous, exhausting and nerve-racking labor so common in the manufacture of most articles of glass. It has therefore proved a boon to the artisans who produce the *flat glass* that plays such an important part in the life of every community.



LIBBEY-OWENS PROCESS: TRIMMING THE SHEET

## CHAPTER VIII

### FLAT GLASS AND PROGRESS

HAT human value has this very modern art of the drawing of flat glass and the accompanying art of window glazing? It is not only that the common use of glazed windows makes homes brighter, more cheerful, more livable in a hundred ways, letting in the sunshine with its purifying properties and its warming, vitalizing influence on body and soul. That is of inestimable value—a value not to be sensed even remotely, except by contrasting the cottage of today with the gloomy, disease-infected hovels of the common people of only three centuries ago. The value of window glazing is even more important than that.



LIBBEY-OWENS PROCESS: CUTTING UP THE SHEET

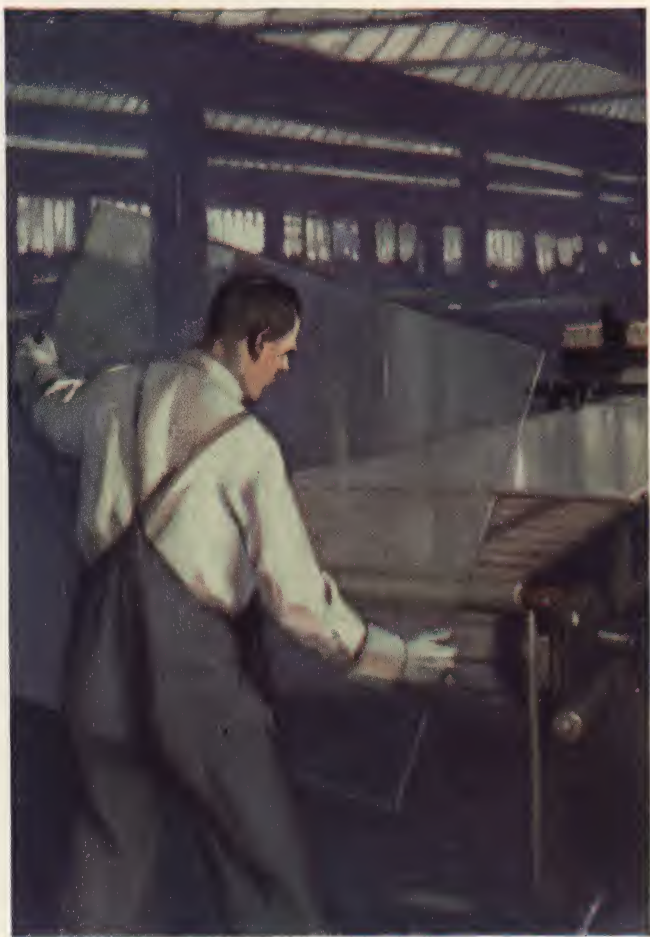


## FLAT GLASS AND PROGRESS

Compare the few small panes set in marble in the greatest of ancient churches with the tremendous fenestration of our modern steel frame factories where production can be carried on by daylight, in climate under human control, no matter what the outside weather may be. Window glass has not only improved the living conditions of man but has contributed tremendously to the development of modern industry.

Professor R. E. Danforth, of Rutgers College, has said in the *Scientific Monthly*: "The great change in home life and the change in industrial life, and in the industries themselves could not begin until an abundance of cheap glass filled all homes with a flood of daylight, and all shops and offices and factories as well, keeping in the artificial heat at the same time. A host of new industries sprang into being in the wake of window glass, and these begat other industries, scientific inventions and discoveries, with magic





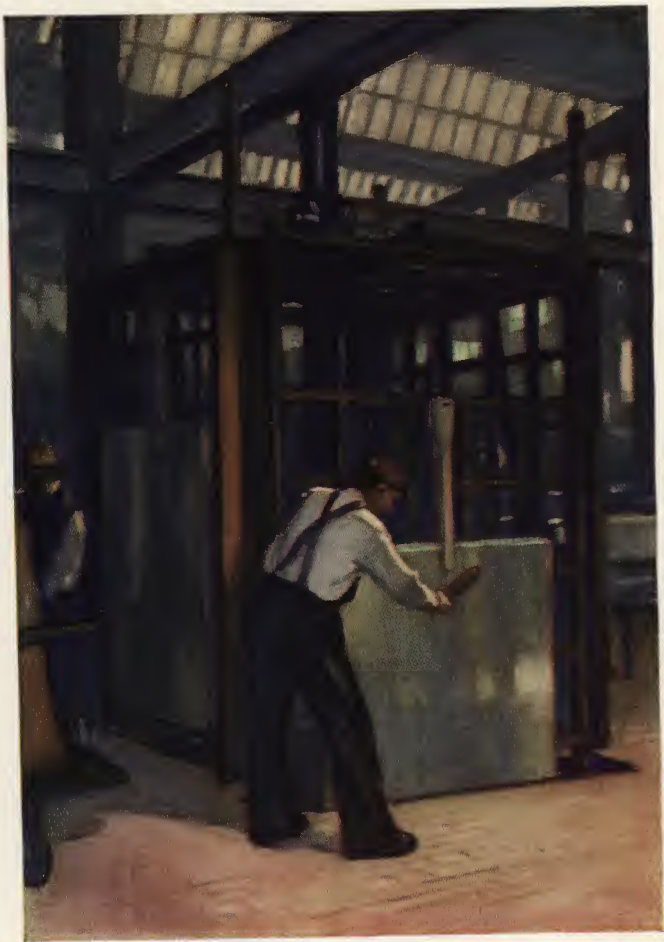
LIBBEY-OWENS PROCESS: SHEETS READY FOR THE CUTTING ROOM

## FLAT GLASS AND PROGRESS

rapidity. The general use of window glass is a thing of yesterday, and in its train there now follows a striking pageant of industrial revolutions, large factories were made possible, big business began, and the physical conditions of home life were completely changed.

“With window glass, industry in shop or office could go on without a break caused by the weather, and, what is of still greater consequence, without the long winter hiatus, during which bright thoughts could be forgotten and the best of intentions fade away.”

So window glass has brought control of the weather, and controlled weather means continuity of effort in labor and invention, which means production on the modern scale. Nor is this control confined to buildings. Portholes of ships, windows of railway cars, the glazed bodies of automobiles, all furnish shelter, warmth, and light to keep men well and comfortable while going about the business of the world.



LIBBEY-OWENS PROCESS: THE ACID BATH

# LIBBEY-OWENS INSTALLATIONS

1924

	NO. OF MACHINES
Libbey-Owens Sheet Glass Company, Charleston, West Virginia	18
America-Japan Sheet Glass Company, Futashima, Japan	- - 3
Canadian Libbey-Owens Sheet Glass Co., Hamilton, Ontario	- 2
The Fairfield Sheet Glass Company, Lancaster, Ohio	- - - 1
United States Sheet & Window Glass Co., Shreveport, La.	- - 6
Compagnie Internationale pour la Fabrication Mecanique du Verre, Moll, Belgium	- - - 6
Compagnie des Verreries de Moutier pour la Fabrication Mecanique du Verre, Moutier, Switzerland	- - 1
Campania Espanola para la Fabricacion Mecanica del Vidrio, San Adrian del Besos, Spain	- - - 1
Compagnie Franco-Belge pour la Fabrication Mecanique du Verre, St. Etienne, France	- - - - - 2
Compagnie Franco-Belge pour la Fabrication Mecanique du Verre, Lens, France	- - - - - 4







